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ABSTRACT

Because analogical reasoning plays a major role in content area reading comprehension, teachers should learn to teach analogy-solving skills and to identify the kinds of difficulties some elementary students will have in solving them. Analogies are statements of relationships wherein one term is similar to another term. Relationships in analogy problems include association, purpose, cause and effect, part to whole, part to part, action to object, object to action, synonym, antonym, place, degree, characteristic, sequence, grammatical, and numerical. Terms in analogies may be verbal or nonverbal (including numbers and figures), and there are many different forms in which the questions may appear. Solving analogies teaches students to think clearly and discriminate relevant from irrelevant material, skills which are useful in many subject areas. Teachers must carefully model analogy solving, because if students misapply strategies for solving analogies or are too novel or creative in their reasoning, they will perform poorly on tests of inference skills. Teachers should (1) show students the kinds of relationships analogies include, (2) acquaint them with the forms and types of analogies they may encounter, (3) guide them through exercises, (4) monitor their practicing, (5) encourage them to form their own analogies in the context of their reading, and (6) devise activities which promote the principal abilities that underlie intelligent behavior. This will help students do well on standardized tests and reason with more cognitive sophistication. (An appendix listing principal abilities underlying intelligent behavior and a reference section conclude the document.) (SKC)

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Teaching Students to Solve Analogy Problems: Increasing Their Skills in Reasoning and Making Inferences

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Introduction

Analogies are statements of relationship wherein one term is similar to another term. " The statement of an analogy is a proportion in which the relationship of the terms on one side of the proportion is similar to the relationship of the terms on the other side of the proportion" (Steinberg, 1985, p.2). Researchers have shown that the ability to solve analogies is among the best indicators of overall intelligence (Wagner and Sternberg, 1984). The purpose of most analogy problems is to test students' reasoning abilities by assessing the extent to which they can see the relationship between two terms and apply that relationship to two other terms.

In general, the new knowledge that students acquire is interpreted on the basis of their existing knowledge (Rumelhart & Norman, 1981). By learning to solve analogies, students learn to attach new knowledge to existing knowledge and thus make inferences which will aid their comprehension of new concepts.

Inference skills, including analogical reasoning, have been found to play a major role in reading comprehension across the content areas (Carr, 1983). The present paper will discuss and illustrate the ways that students can be taught to use analogies in order to increase their level of reading comprehension and ability to make inferences in a variety of content areas. As a result of learning to solve problems via analogical reasoning, students think more precisely and can make more sophisticated analyses, explanations and hypotheses within a particular content area. The present paper will also discuss the kinds of difficulties some students have processing analogies. Finally, future directions for research on analogical reasoning will be presented.

Analogies are statements of relationships wherein one term is similar to another term. Analogy questions test students' abilities to see a relationship between words and apply this relationship to other words. They require students to infer a relation, and then use that relation to complete a new one. When analogies are used as a problem solving method, students attempt to use the structure of the solution to one problem to guide solutions to another problem. Put another way, students use the relationships they see in one context or situation to assist them in understanding another situation or relationship. Analogy questions focus on different relationships, include two types of terms --verbal or nonverbal, and are presented in various forms on examinations.

The kind of relationship that exists between the first two terms in analogy questions may be one of several possible types. The relationships include: association, purpose, cause and effect, part to whole, part to part, action to object, object to action, synonym, antonym, place, degree, characteristic, sequence, grammatical and numerical (Gruber, 1967). Steinberg (1985) listed whole to part, effect and cause, and function as common analogy relationships in addition to the above stated ones which she and Gruber had in common.

Sternberg (1986) referred to the types of relationships used in analogy questions by devising a classification system to assist students in solving analogies. The thirteen types of relationships he noted were: similarity, contrast, predication, subordination, coordination, superordination, completion, part-whole, whole-part, equality, negation, word relations, and nonsemantic relations. The point that the present authors seek to make is that analogies lend themselves to specific categorization, as can be noted by an examination of the three authors' lists. This categorization could be

instrumental in teaching students how to solve analogies.

The terms of an analogy may be verbal or nonverbal; nonverbal analogies may be numbers or figures. Verbal analogies are the most popular of the two types. In any one analogy, all terms are of the same type, i. e., all words, all numbers or all figures.

Analogy questions have various forms; students must complete a statement of relationship which is incomplete. Steinberg discussed four types of analogy problems. In the first type, the student must solve the fourth term of the analogy. An example of such an analogy is: apple is to fruit as spinach is to

(A) meat

(B) vegetable

(C) bread

(D) cereal

(The correct answer is (B).)

The second type problem requires students to supply any one of the four missing terms. An example of such an analogy is:

Huge: large ::_____: small

(A) tiny

(B) big

(C) wide

(D) sharp

(The correct answer is (A).)

In the third type of analogy problem. students must supply the second set of terms because a pair of terms is missing. An example of this type of analogy is: up: down ::

(A) go: start

(B) chilly: cold

(C) win: lose

(D) east: south

(The correct answer is (C).)

The fourth type of analogy requires students to supply the correct response where any two terms are missing. An example of this type analogy question is: _____is to cold as rain is to _____.

(1)light (2)warm (3)snow (4)star

(A)star (B)night (C)shine (D)wet

(The correct answer is (3) (D).)

THE PURPOSE OF ANALOGIES

Analogy questions test students' ability to think clearly and discriminate between relevant and irrelevant material and information. Standardized analogy tests assess reasoning abilities; they require logical processing and draw upon objective, socialized knowledge (Jorgensen, 1980). For young students, the ability to see relationships indicates that the student is able to reason. As students age and mature, the skills that analogy questions seek to measure increase in difficulty and complexity; proficient reasoning skills are the result of growth and maturation.

The general strategy of problem solving by analogy has been found to be useful for learning in domains such as text editing, insight problems, probability, and geometry (Gick, 1986). Teaching students to solve analogies provides them with a strategy that promotes transfer of attributes from a familiar topic to an unfamiliar one. Skills in analogy problem solving could help in improving students' memory, encourage more critical evaluation of information and increase students' specific information (Devall, 1980). Various authors have examined the uses and functions of analogies. Following is a brief outline of what five authors have noted.

According to Gruber (1967), analogies:

Assess vocabulary

Test the ability to think things out

Assess the ability to think clearly

Measure the ability to sidestep confusion of ides

Test ability to distinguish that which is general from that which is specific

Test ability to see a relationship between words and to apply this relationship to other words

According to Jorgensen (1980), analogies:

Help students concretize their thinking

Gauge how students understand information

Tap and develop a facility for visual thinking

Exercise and nurture creative and critical thinking

Clarify and organize unfamiliar subject matter

Allow convergent and divergent thinking

Involve higher level analyses and synthesis of material

According to Devall (1983), analogies:

Improve memory and vocabulary

Provide a strategy for transfer of attributes from a familiar to an unfamiliar topic

Increase specific knowledge

Encourage critical evaluation of information

Help students understand health and science

Teach analytical reasoning

Develop concepts in the content areas

According to Steinberg (1985), analogies:

ELEMENTARY LEVEL

Measure the ability to think clearly and creatively

Test reasoning ability

Gauge the ability to see the relationship between two terms and to apply that relationship to two other terms

LATE ELEMENTARY AND JUNIOR HIGH

Test reasoning abilities

MIDDLE SCHOOL AND JUNIOR HIGH

Test the understanding and manipulation of relationships

COLLEGE

Test reasoning ability and vocabulary

Test the understanding of words

According to Sternberg (1986), analogies:

Require recognition of higher-order relation between two lower order relations

For the purposes of the present paper, the focus is on analogies at the elementary level, specifically third grade. Third graders who are in school which use Harcourt Brace Jovanovich's reading series are presented with reading comprehension skills such as: recognizing cause and effect, recognizing word meaning in context, inferring to draw conclusions, inferring to predict outcomes, making analogies, and recognizing multiple meaning of words. Activities are presented in the reading texts which seek to teach these skills. Some examples include: Recognizing cause and effect

> Wee Gillis spent alternating years as sheep raiser and as deer stalker to see which occupation he liked best. What happened as a result of his year calling sheep?
> (Wee Gillis)

> Inferring to predict outcomes
> What are some of the events of Amelia's life? Before you read about them, did you predict that any of these things would happen? Which ones did you predict? What clues in the story and in the introduction to the story helped you to make these predictions?

(Amelia Earhart, First Lady of Flight)

Making analogies

Ask students to complete this sentence: Boats are used in the water, and planes are used in the _____. (sky)

Point out that the skills and methods a detective uses are similar to those used by people in other professions.

In many ways, the use of analogies as a systematic way to increase students' performance and understanding has been overlooked and somewhat underemphasized. Analogies are used frequently in daily life to explain concepts in conversations; teachers use them to introduce new ideas. If analogies were utilized more consciously by teachers, students would learn skills of inference and analogical reasoning as they are learning other skills in reading such as language skills, study skills, decoding, comprehension and literature appreciation.

In an article where parents were given various ways to assist their offsprings' success in school, Lustiz (1984) listed the following strategies:

1. Make up questions
2. Make inferences
3. Create analogies
4. Find the main idea
5. Categorize information.

Of the five suggestions he presented, the strategies 'make inferences' and 'create analogies' were of specific interest to the authors of the present paper.

Inference is a comprehension skill that maintains a major role in reading comprehension. Inference involves the discovery of one or

more relations between objects or events (Sternberg, 1986). Justiz (1984) stated that when students make inferences, the new material and information they are acquiring becomes more meaningful and thus is more easily remembered. The ability to draw inferences from reading or listening develops from early childhood to adulthood and is closely linked to background experience (Carr, 1983).

In addition to the experiential background, students' abilities to effectively make inferences depends upon their age, and whether or not questions are used as a way to probe for elicitation of inferences. Teachers may have to ask questions initially during lessons in order to help students exercise inferences and making associations. As students are continuously exposed to questioning, they will begin to think of questions automatically. Such internalization will ultimatley lead to better comprehesion and thus better analogical reasoning and inferential abilities. When teaching reading, teachers must be cognizant of the difficulty level of the selection or story which the stduents are asked to read. One way to accomplish this is to analyze the number of inferences that students must make in a given selection.

Inference in solving verbal analogies takes place because the student has to infer a relationship between two terms. Justiz (1984) elaborated on the strategy 'create analogies' referred to above, by encouraging parents to make the suggestion to their children to think about things that they know relate to the new information they are seeking to acquire. This suggestion has relevance for classroom teachers. Students can be encouraged to apply the information they read in stories to past stories they have heard or read, past situations in which they or a family membered encountered, or to television shows they have seen. By associating new knowledge in such a meaningful way to knowledge that they already have, students are

increasingly likely to retain the new information

DIFFICULTIES IN SOLVING ANALOGIES

Analogy problems offer many opportunities for error if every answer is not given careful consideration (Steinberg, 1985). Common errors that analogy problem solvers make are reversal of sequence of the relationship, confusion of the type of relationship, grammatical inconsistency and concentration on the meaning of words as opposed to their relationship. If students are creative, free associative and capable of generating novel and original parallels between the terms of an analogy problem, they will probably perform poorly on analogy tests (Jorgensen, 1980).

Students' reasoning abilities suffer breakdowns when they do not make use of relevant facts and because of lack of strategies in acquiring new information (Devall, 1980). In analogical reasoning, the rules change from problem to problem and the relationship in question may cross domains.

THEORIES TO SOLVE ANALOGIES

There are various theories for analogy solution which educators need to be aware of in order to best assist their students in analogy problem solving -- especially since this ability focuses on skills of inference and analogical reasoning. Various authors have given suggestions for students to use as strategies for successful completion of analogy questions. These are described below.

Gruber (1967) stated two important steps to analogy success: determine the relationship between the first two words and find the same relationship among the choices which follow the first two words. Sternberg (1984) stated that students use metacomponential processes to solve analogies. These include deciding which process to use, deciding how the processes should be sequenced, inferring the relationship between the first two terms of the analogy, mapping the

relation they have inferred in the fisrt part of the relationship to the second part of the relationship, applying the relation that was inferred and mapped so as to select the best possible alternative.

Steinberg (1985, p. 7) stated the following procedural steps, which may be changed to account for differences in the type of relationship that was initially defined, to solve verbal analogy problems:

1. Define the initial relationship
2. Describe the initial relationship
3. Eliminate incorrect responses
4. Refine the initial relationship, if necessary.
5. Choose the best answer.

When students redefine the relationship, the analogy problem maintains the parellelism among terms and allows them to rethink the relationship if necessary.

Devall (1980) outlined three steps needed in solving analogy problems. She stated that students must understand the first three parts of the analogy, determine the relationship between the first pair, and then introduce the relationship to the second pair of terms in order to successfully complete the question.

ROLE OF THE TEACHER

Given that students need to have proficient analogical reasoning and inference abilities, what can teachers do? The present authors make the following suggestions in light of the brief review of literature presented in this paper.

1. Familiarize students with the various relationships that analogies include.
2. Acquaint students with the various forms and types of analogies they may encounter.
3. Guide them through various exercises as presented in their

reading series.

4. Monitor students practice of recognizing relationships by providing them with activities that will serve as supplements to the activities they complete as part of their reading lesson.
5. Encourage students to practice these skills independently by forming their own analogies either in the context of an existing story or in the context of topics of personal interest.
6. Devise activities which promote the principal abilities which underlie intelligent behavior (Sternberg, 1986) (see Appendix I).

TESTS WHERE ANALOGIES APPEAR

As mentioned earlier, analogical reasoning is explicitly measured in various types of standardized tests. These include college entrance examinations, civil service tests and intelligence tests. More specifically, the Scholastic Aptitude Test (SAT), Graduate Record Examination, Miller Analogy Test (MAT), Medical College Admission Test (MCAT), Woodcock-Johnson Psychoeducational Battery, and the Ross Test of Higher Cognitive Processes measure students' abilities to reason. Since standardized testing is used so pervasively to determine whether students pass from one grade to the next, receive academic scholarships, and attend graduate and post-graduate school, improving ability in analogical reasoning will increase students' performance.

FUTURE RESEARCH: A RESEARCH PROPOSAL

After reading the present paper which presented characteristics of analogies and their significance in increasing students' abilities in reasoning and making inferences, and contemplating the suggestions offered by researchers, many interesting research questions may be raised: How should reasoning skills, which develop precision with a students' growth, age and maturation, be enhanced in order to assist students in achieving maximully in all content areas? When is

analogical reasoning and inferences skills training necessary? Can students who exhibit high analogical reasoning skills based on their standardized test scores apply these skills to a more difficult situation or task ? What genralizations do students make when attempting to solve analogy problems? Do these generalizations assist them in solving problems? Are there differences between Black students' analogical reasoning and inference skills and those of their White counterparts? Do male students solve numerical analogies better than female students? These questions indicate the various information that could be gained through con inued research in this area. Analogical reasoning and prblem solving will be examined and contemplated further for the first author's upcoming doctoral dissertation.

The importance of increasing students' productivity and performance in school is a fact not overlooked by teachers, educators, administrators and researchers. Students can be taught ways to use analogies in order to increase their skills in reading comprehension and making inferences in many content areas. Students who learn to solve problems by analogical reasoning will be able to apply these abilities to tasks that are required of them in the future--standardized tests, classroom projects, or teacher-made tests. Their thinking will increase in precision, and they will learn to analyze, explain and hypothesize in content areas using more cognitive sophistication.

APPENDIX I

PRINCIPAL ABILITIES UNDERLYING INTELLIGENT BEHAVIOR

1. Recognizing and defining the nature of the problem
2. Deciding upon the processes needed to solve the problem
3. Sequencing the processes into an optimal strategy
4. Deciding upon how to represent problem information
5. Allocating mental and physical resources to the problem
6. Monitoring and evaluating ones's solution processing
7. Responding adequately to external feedback
8. Encoding stimulus elements effectively
9. Inferring relations between stimulus elements
10. Mapping relations between relations
11. Applying old relations to new situations
12. Comparing stimulus elements
13. Responding effectively to novel kinds of tasks and situations
14. Effectively automatizing information processing
15. Adapting effectively to the environment in which one resides
16. Selecting environments as needed to achieve a better fit of one's abilities and interests to the environment
17. Shaping environments so as to increase one's effective utilization of one's abilities and interests

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